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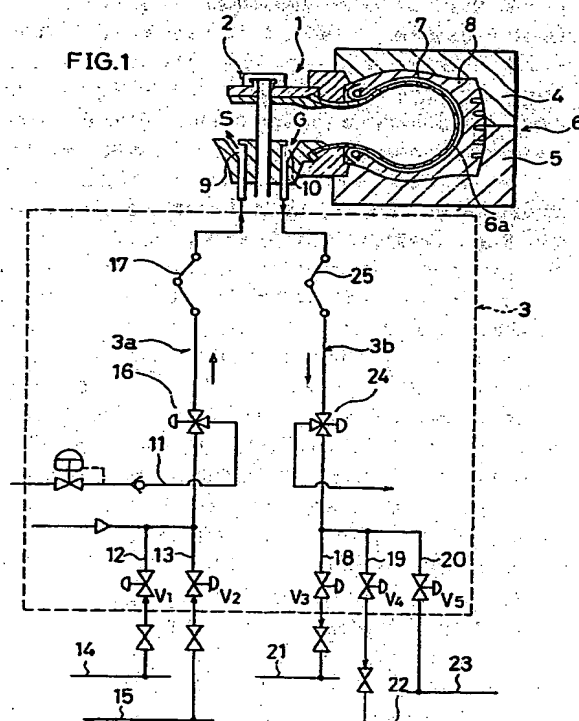
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### Method for vulcanising an elastomeric product.

A method for vulcanising an elastomeric product placed in a vulcanising means includes one step of supplying heating medium into the elastomeric product and another step of supply pressurising medium into the elastomeric product at a higher pressure than the heating medium, the two steps being performed one after another at least twice. This method can produce an elastomeric product having no bareness without increasing the vulcanising time.

FIG.1



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## METHOD FOR VULCANISING AN ELASTOMERIC PRODUCT

This invention relates to a method for vulcanising an elastomeric product using gas as a pressurising medium.

In a conventional method, an elastomeric product, such as a tyre for a vehicle, is vulcanised by the steps of placing the elastomeric product in a mould with a bladder, beginning to close the mould feeding shaping pressure into the bladder so as to bring the elastomeric product into contact with the inner surface of the mould by means of the inflated bladder, supplying steam as a heating medium into the bladder after the mould is completely closed, stopping the supply of steam either when the temperature of the elastomeric product rises to a predetermined level or after a lapse of a predetermined time, supplying combustion gas or nitrogen gas as a pressurising medium at a pressure equal to or higher than that of the steam, and discharging the mixture of heating medium and the pressurising medium after a lapse of a predetermined time. In such a vulcanisation, pipe inlets supplying the pressurising medium and the heating medium are opened, while pipe outlets for discharging the pressurising medium and the heating medium are kept closed. Also, the heating medium to heat the elastomeric product from the inside is only steam. The gas is utilised purely for pressurisation.

In the case where the elastomeric product is a large size tyre, more heat is necessary from the inside than for a smaller tyre. This is because a large size tyre has greater thickness than smaller one. Accordingly, a longer heating time is usually required for a large size tyre than for a smaller one.

It is usual that the steam is supplied at a pressure of 13 to 15 kg/cm<sup>2</sup> and the gas is supplied at a pressure of 18 to 28 kg/cm<sup>2</sup>. Accordingly, the pressure of steam is lower than that of the gas.

In the case of vulcanising a large size tyre having a greater thickness, it is preferable from a viewpoint of the time to change from the heating process to the pressurising process at as early a stage as possible after starting the heating process. This is because of the trouble due to air in rubber and bareness which can occur in the cured tyre. However, if the heating time is cut short, the thermal input given to the tyre will become less and after all the vulcanisation will end up either with a long cure time being needed to make up for the thermal input shortage or an under cure problem.

It is an object of the present invention to provide a method for vulcanising an elastomeric product which makes it possible to prevent air from being trapped in the elastomeric product and/or between the mould surface and the elastomeric product, or a bareness from occurring, and to cure

the elastomeric product without prolonging the cure time.

According to the present invention, a method for vulcanising an elastomeric product placed in vulcanising means comprises one step of supplying heating medium to the elastomeric product and another step of supplying pressurising medium to the elastomeric product at a higher pressure than the heating medium characterised in that the two steps are performed one after another at least twice.

The method of the present invention may comprise supplying pressurising medium to the elastomeric product and then supplying the heating medium to the elastomeric product, supplying the pressurising medium to the elastomeric product, supplying the heating medium to the elastomeric product, and supplying the pressurising medium to the elastomeric product.

In the methods of the present invention, the heating process is performed at least two times, and the pressurising process is performed two times or more. In an early stage of vulcanisation, when the rubber is fluid owing to temperature rise but it is not vulcanised, the pressurising process in which the pressurising medium at a higher pressure than the heating medium is supplied is performed.

At the stage when the air trapped in the elastomeric product and/or between the mould surface and the elastomeric product has been eliminated or there is no longer the danger of generating bareness on the surface of the elastomeric product, in other words, when it is perceived judging from the outside appearance of the elastomeric product that the rubber fluidity has come to an end, heating pressure is applied again.

Accordingly, the method of the present invention can produce an elastomeric product having no bareness without adding to the cure time.

The above and other objects, features and advantages of the present invention will become apparent from the following detailed description by way of example only, with reference to the accompanying drawings in which:-

Fig.1. is a schematic diagram of a vulcanising apparatus in which the method for vulcanising an elastomeric product of the present invention is carried out

Fig.2. is a diagram showing another discharge section of the vulcanising apparatus of Fig. 1.

Fig.3. is a graph showing comparatively the temperature rises of elastomeric products under four different vulcanisations

Fig.4. is a graph showing pressure changes in bladders under the four different vulcanisations

Fig.5. is a graph showing temperature rises of an elastomeric product under another vulcanising method of the present invention.

Fig.6. is a graph showing a pressure change in a bladder under the another vulcanising method of the present invention and

Fig.7. is a graph showing the vulcanising rate in a surface portion of an elastomeric product.

The vulcanising apparatus 1 includes a vulcanising unit 2 and a piping system 3. The vulcanising unit 2 includes a mould 6 having an upper mould and a lower mould 5, and a bladder 7 made of rubber. An elastomeric product 6a is defined by the mould 5 and the bladder 7. A raw tyre 8, which is the elastomeric product to be vulcanised, is placed in the vulcanising chamber 6a. After being placed in the vulcanising chamber 6a, the raw tyre 8 is heated and pressurised to vulcanised the rubber. However, it should be noted that the tyre 8 shown in Fig.1 is illustrated not as a raw tyre, but as an already vulcanised tyre or a tyre being vulcanised. Also, it should be noted that the present invention can be performed in a vulcanising apparatus without using a bladder.

The vulcanising unit 2 has a blowing input opening 9 and a discharging opening 10 which are communicated with respective vulcanising medium sources (not shown) by way of a piping system 3. The piping system 3 is roughly divided into a supply section 3a for supplying the vulcanising medium to the vulcanising unit 2 and a discharge section 3b for discharging the vulcanising medium from the vulcanising unit 2.

The supply section 3a includes a preshaping fluid supply pipe 11 for supplying a preshaping medium, such as gas, or steam and a pressurising medium supply pipe 12 for supplying a pressurising medium, such as nitrogen gas or combustion gas, and a heating medium supply pipe 13 for supplying a heating medium, such as steam.

The pressurising medium supply pipe 12 is communicated with a main gas pipe 14 by way of a first valve V1. The heating medium supply pipe 13 is communicated with a main steam pipe 15 by way of a second valve V2. The pressurising medium supply pipe 12 and the heating medium supply pipe 13 are communicated with the blowing opening 9 by way of a valve 16 and a flexible pipe 17. Also, the preshaping medium supply pipe 11 is communicated with the blowing opening 9 by way of the valve 16.

The discharge section 3b includes a drain discharge pipe 18, a gas discharge pipe 19, and a vacuum pipe 20. the drain discharge pipe 18 is communicated with a drain main pipe by way of a third valve V3. the gas discharge pipe 19 is communicated with a discharge gas main pipe 22 by way of a fourth valve V4.

The vacuum pipe 20 is communicated with a vacuum main pipe 23 by way of a fifth valve V5. The drain discharge pipe 18, the gas discharge pipe 19, and the vacuum pipe 20 are communicated with the discharging opening 10 by way of a valve 24 and a flexible pipe 25.

Also as shown in Fig. 2, it is possible to connect a gas recovery pipe 26 to the gas discharge pipe 19 to recover the discharge gas to reuse it as preshaping gas. In this case, another gas discharge pipe 27 is provided and it is communicated with the discharge gas main pipe 22 by way of a sixth valve V6.

Next, the vulcanising method of the present invention will be described which is carried out with the use of the above-mentioned vulcanising apparatus 1.

As a first step the raw tyre 8 is placed in the mould 6. Subsequently, the upper mould 4 and the lower mould 5 are closed, which means the moulds are coupled and pressed against each other at a predetermined pressure, while performing the preshaping process.

Next, the raw tyre 8 is heated by supplying steam as a heating medium into the bladder 7 by closing the valves V1, V3, V4, and V5, and opening the second valve V2.

The steam is supplied at a pressure of 14 kg/cm<sup>2</sup> for 2 minutes.

Thus a first heating process is performed.

The third step when the surface portion of the tyre 8 has a cure rate (ECU) of 15 percent or less e.g. after a lapse of 2 minutes after supplying the steam, the valve V1 is opened and the valve V2 is closed so that gas as pressurising medium is supplied into the bladder 7. The gas is supplied at a pressure 20kg/cm<sup>2</sup> for 13 minutes. Thus a first pressurising process is performed. The bladder 7 is consequently filled with a mixture of the steam and the gas.

The fourth step, when air trapped in the tyre or between the tyre 8 and the mould 6 has been discharged, or when the rubber fluidity comes to an end, is that the mixture is replaced with steam (heating medium) by closing the valve V1 and opening the valves V2 and V3. the steam blowing is performed for 1 minute. Thereafter, the valve is closed and steam is again supplied at a pressure of 14 kg/cm<sup>2</sup> for 1 minute to heat the tyre 8. Thus a second heating process is performed.

The fifth step, when the tyre 8 is supplied with enough heat or thermal input to complete vulcanisation, the valve V2 is closed and the valve V1 is opened to supply gas. The gas is supplied at a pressure of 20 kg/cm<sup>2</sup> for 28 minutes. Thus a second pressurising process is performed.

The sixth stage is to close valve V1 and open valve V4 so that a mixture of steam and the gas, or

the has alone is discharged from the bladder 7 for a predetermined time, e.g. 30 second. Namely a discharge process is performed.

The next and seventh step is to close valve V4 and open valve V5 so that the mixture of the steam and the gas, or the gas is sucked out by the vacuum of the bladder 7 for a predetermined time, e.g. 30 second. Thus a vacuuming process is performed. After the pressure in the bladder 7 becomes pressure, the mould 6 is opened and the vulcanised tyre 8 is removed from the vulcanising unit 2.

As mentioned above, the first heating process (14 kg/cm<sup>2</sup> for 2 minutes) the first pressurising process (20 kg/cm<sup>2</sup>, for 13 minutes), the steam blowing process (1 minute), the second heating process (14 kg/cm<sup>2</sup>, for 1 minute) the second pressurising process (20 kg/cm<sup>2</sup>, for 28 minutes), the discharging process (30 second), and the vacuuming process (30 seconds) are performed in the order mentioned above.

The steam blowing is performed to discharge the pressurising medium (nitrogen gas) from the bladder 7 and to ensure the entire replacement of the pressuring medium with the heating medium (steam). In other words, the steam blowing is performed to assure the second heating process which compensates for an insufficient heat supply from the first heating process which has been cut short.

The reason why the first heating process is terminated when the surface portion is at a cure state (ECU) of 15 percent or less is that the rubber fluidity occurs in the vulcanisation rate of 15 percent or less as shown in Fig.7. Also, it is most effective and easiest to perform steam blowing to replace the pressurising medium with the heating medium. The second heating process is switched to the second vulcanising process when the time set in advance so as for the tyre temperature to reach a predetermined level necessary for vulcanisation in the second heating process has elapsed. The temperature level necessary for cure is determined in consideration of the critical temperature of the components of the tyre and vulcanisation time.

Fig.3. shows the temperature rise at two points A and B of tyres which are vulcanised in accordance with the method of the present invention, a first comparison method, a second comparison method, and a third comparison method. Point A refers to the position in an inner liner of the tyre where temperature rises slowest and Point B refers to a position in the inner liner where temperature rises fastest. Curves drawn with broken lines show the temperature of a tyre according to the present invention. Curves drawn with solid lines show the temperature of a tyre according to the first com-

parison method. Curves drawn with one dot chain lines show the temperature of a tyre according to the second comparison method. Curves drawn with two dot chains lines show the temperatures of a tyre according to the third comparison method.

In the first comparison method, a raw tyre was heated and pressurised by use of hot water having a pressure of 20 kg/cm<sup>2</sup> and a temperature of 180 °C for 45 minutes. In the second comparison method, a raw tyre was heated at a pressure of 14 kg/cm<sup>2</sup> for 20 minutes, and then pressurised at a pressure of 20 kg/cm<sup>2</sup> for 25 minutes. In the third comparison method, a raw tyre was heated at a pressure of 14 kg/cm<sup>2</sup> for 2 minutes, and then pressurised at a pressure of 20 kg/cm<sup>2</sup> for 43 minutes. Fig.4 shows respective pressure changes in bladders of the present method, first comparison method, second comparison method, and third comparison method.

From the graphs shown in Fig.3 and Fig.4, the following will be seen.

By comparing the present method to the first comparison method of hot water vulcanisation, the present method can be seen to provide substantially the same temperature rise as the first comparison method of the hot water vulcanisation. Also, the pressure in the bladder can be increased to the high value a sort time from the start of vulcanisation. Accordingly, the present method can obtain substantially the same vulcanisation time as the hot water vulcanisation without degrading the quality of tyre.

By comparing of the present method to the second comparison method, the present method can be seen to increase the pressure in the bladder to the high value in a shorter time from the start of vulcanisation than the second comparison method. Also, the present method can give substantially the same thermal input value (quantity of heat) to the tyre as the second comparison method. Accordingly, the present method can obtain as short a vulcanisation time as the second comparison method, and eliminate air trapping and bareness.

By comparing the present method to the third comparison method, the third comparison method can be seen to attain the high bladder pressure in the same time from the start of vulcanisation as the present method. However, the third comparison method has a longer vulcanisation time in total due to the fact the shortage of heat quantity resulted from the heating process of the third comparison method being performed for no more than 2 minutes has to be made up for.

In the present method, as shown in Fig.4, the pressure in the bladder lowers to about 13 kg/cm<sup>2</sup> at a mid time of the vulcanisation process, specifically, after the lapse of 15 to 17 minutes from the

start of vulcanisation. However, in hot water vulcanisation using cooling water or other vulcanisations, the bladder pressure will generally drop to such a value, which causes no trouble with the quality of tyre. Further, this pressure drop can be presented by making the diameter of the pipe for steam blowing smaller, or providing the pipe with an orifice.

In the above mentioned method of the present invention, the entirety of the mixture of steam (heating medium) and nitrogen gas (pressurising medium), or the entirety of nitrogen gas (pressurising medium) is replaced with steam by the steam blowing.

However, there is a case where due to a short steam blowing, nitrogen gas (pressurising medium) is not entirely replaced with steam (heating medium). Also, there is a case where due to the existence of a great pressure difference between steam and nitrogen gas, the bladder is entirely filled with only nitrogen gas (pressurising medium) when changing from the heating process to the pressurising process.

In other words, in a case where a heating process is firstly performed, a pressurising process is secondly performed, and another heating process is performed again. It is required that the entirety or a part of the pressurising medium, or the entirety or a part of the mixture of the heating medium and the pressurising medium is replaced with the heating medium supplied in the second heating process. Also, it is preferable to increase the bladder pressure to the high value promptly.

In another method of the present invention, as shown in Fig.5 and Fig. 6, a first pressurising process is performed by supplying pressurising medium having higher pressure than the heating medium. Next, a first process is performed by replacing then entirety or a part of the pressurising medium with the heating medium after a first steam blowing process is performed.

Thereafter, a second pressurising process is performed by supplying the pressurising medium. Next, a second heating process is performed by replacing the entirety or a part of the pressurising medium, or the entirety or a part of a mixture of the pressurising medium and the heating medium with the heating medium after a second steam blowing process is performed. Thereafter, a third pressurising process is performed by supplying the pressurising medium to complete vulcanisation.

Specifically, the first pressurising process is performed at a pressure of 20 kg/cm<sup>2</sup> for 7 minutes. The first steam blowing process is performed for 30 seconds. The first heating process is performed at a pressure of 14 kg/cm<sup>2</sup> for 4 minutes 30 second. The second pressurising process is performed at a pressure of 20 kg/cm<sup>2</sup> for 5 minutes.

The second steam blowing process is performed for 1 minute. the second heating process is performed at a pressure 14 kg/cm<sup>2</sup> for 1 minute. The third pressurising process is performed at a pressure of 20 kg/cm<sup>2</sup> for 26 minutes. The discharging process is performed for 30 seconds. Finally, the vacuuming process is performed for 30 seconds.

In an early stage of the heating process, the heating process is switched to the pressurising process which is performed by the pressurising medium having higher pressure than the switched medium. Also, the pressurising process is changed to the heating process again when air trapped in the tyre or between the tyre and the mould surface has been eliminated, or rubber fluidity has come to an end. Thus a lack of thermal input due to the fact that the initial heating process is shortened can be compensated by the second heating process. Accordingly, the thermal input necessary for vulcanisation can be given without prolonging the vulcanisation time. Thereafter, another pressurising process is performed at a high pressure. Namely, high pressure vulcanisation is completed. In other words, when the raw rubber is fluid due to the temperature rise, vulcanisation is executed at a high pressure. After the trapped air is eliminated, or there is no longer the danger of generating bareness, namely when rubber fluidity comes to an end, another heating process is performed again. Consequently, the surface of the tyre can be formed, perfectly following the mould surface.

This method can prevent air from being trapped in the elastomeric product or between the mould and the product and bareness in the surface portions of the elastomeric product is avoided perfectly.

As mentioned above, the present invention can provide a shortened vulcanisation time. Accordingly, the present invention makes it possible to eliminate air trapping and bareness troubles and also eliminate under cure trouble. Thus, the present invention can produce an elastomeric product having a higher quality with a reduced cost.

In the first method of the present invention, two heating processes and two pressurising processes are performed. In the second method, two heating processes and three pressurising processes are performed. However, it should be noted that the number of heating processes are pressurising processes is not limited in the above-mentioned first and second methods. Also, it should be noted that the time of each process is not limited in the above-mentioned first and second methods.

Although the present invention has been fully described by way of method with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless other-



wise such changes and modifications depart from the scope of the invention, they should be construed as being included therein.

#### Claims

1. A method for vulcanising an elastomeric product placed in a vulcanising means characterized by one step of supplying heating medium to the elastomeric product and another step of supplying pressurising medium to the elastomeric product at a higher pressure than the heating medium characterised in that the two steps are performed one after another at least twice.
2. A method according to claim 1 characterized by supplying the heating medium to the elastomeric product, supplying the pressurising medium to the elastomeric product, supplying the heating medium to the elastomeric product, and supplying the pressurising medium to the elastomeric product.
3. A method according to claim 2 characterized in that the second step is performed when the rubber of a surface portion of the elastomeric product is still fluid.
4. A method according to claim 2 characterized in that the pressure of the pressurising medium is higher than that of the heating medium in the second step.
5. A method according to claim 2 characterized in that the third step is performed when air is discharged from inside or between the elastomeric product and the mould or rubber fluidity has come to an end.
6. A method according to claim 2, 3, 4, and 5 characterized in that the third step, the heating medium is substituted for the all of or part of the pressurising medium, or the whole of or a part of a mixture of the heating medium and the pressurising medium.
7. A method according to claim 2, 3, 4, 5 or 6 characterized in that the fourth step is performed when the thermal value necessary for vulcanisation of the product has been attained.
8. A method according to any of claims 1 to 7 characterized by before first supplying the heating medium to the elastomeric product; supplying pressurising medium to the elastomeric product;

9. A method according to claim 8 characterized in that the second step, the pressurising medium is higher in pressure than the heating medium.

10. A method according to claim 8 wherein in the second step, the heating medium is substituted for the all of or a part of the pressurising medium.

11. A method according to claim 10 characterized in that fourth step, the heating medium is substituted for all of or a part of the pressurising, or all of or a part of a mixture of the pressurising and the heating medium.

**FIG.1**

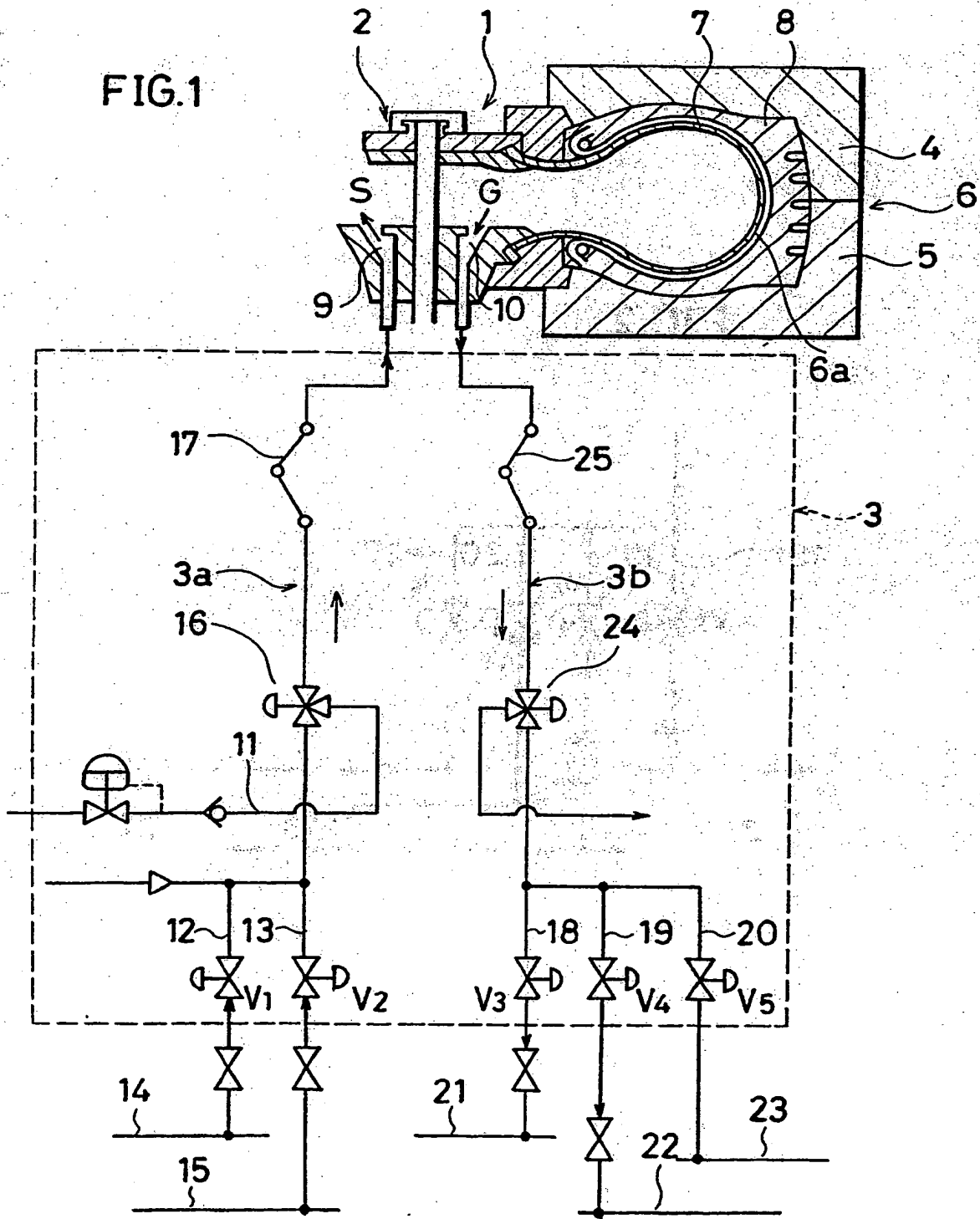




FIG.2

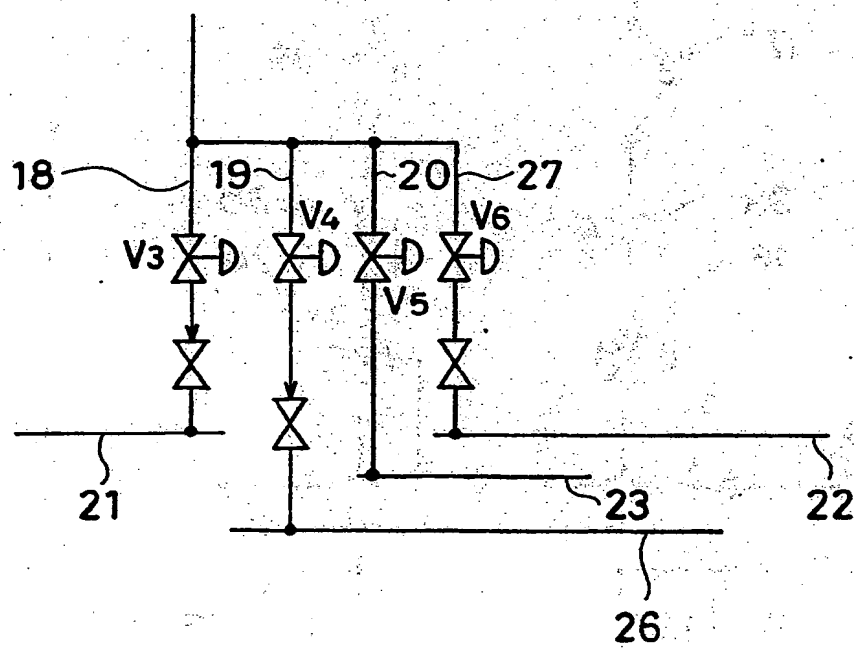


FIG.3

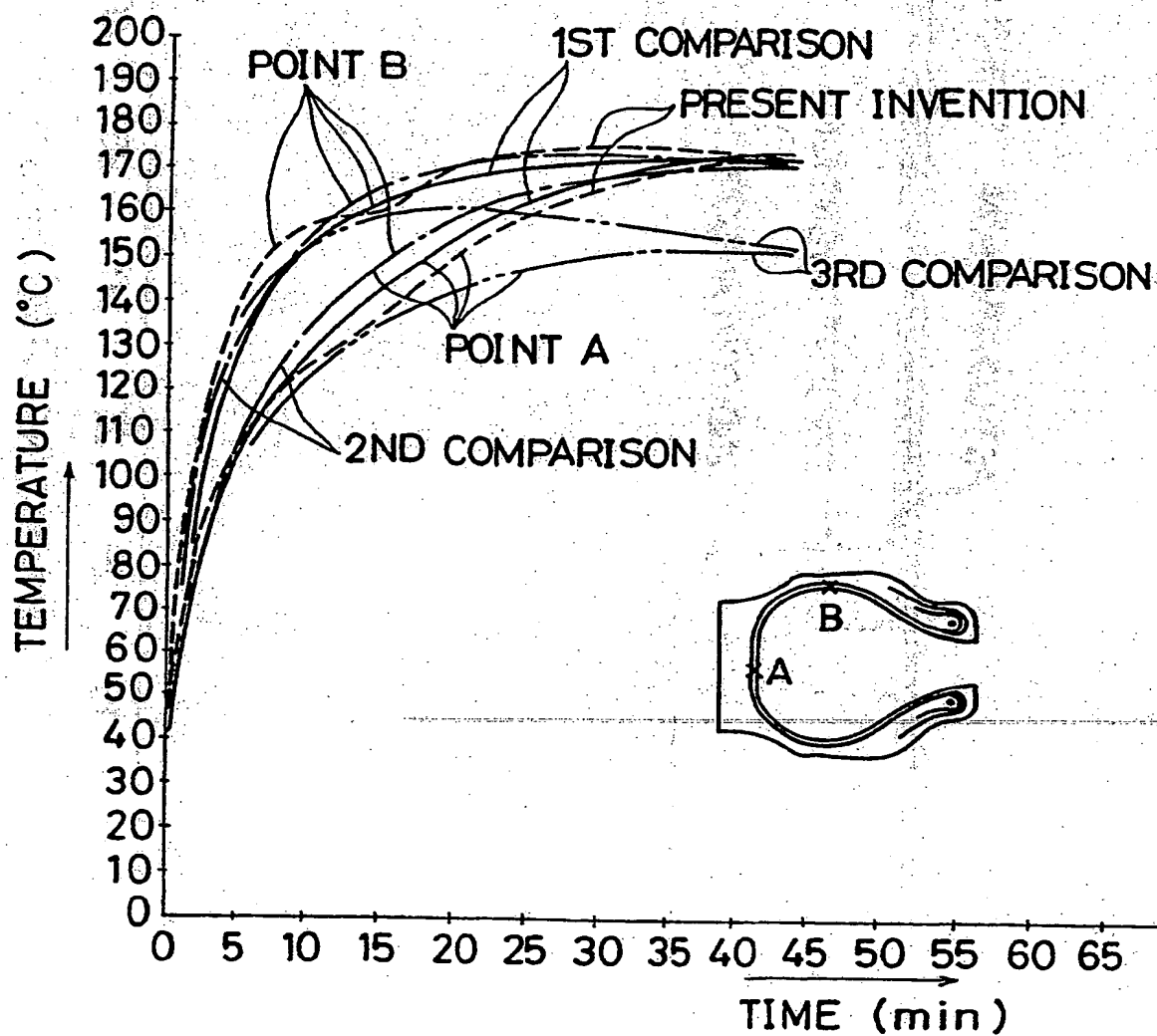


FIG. 4

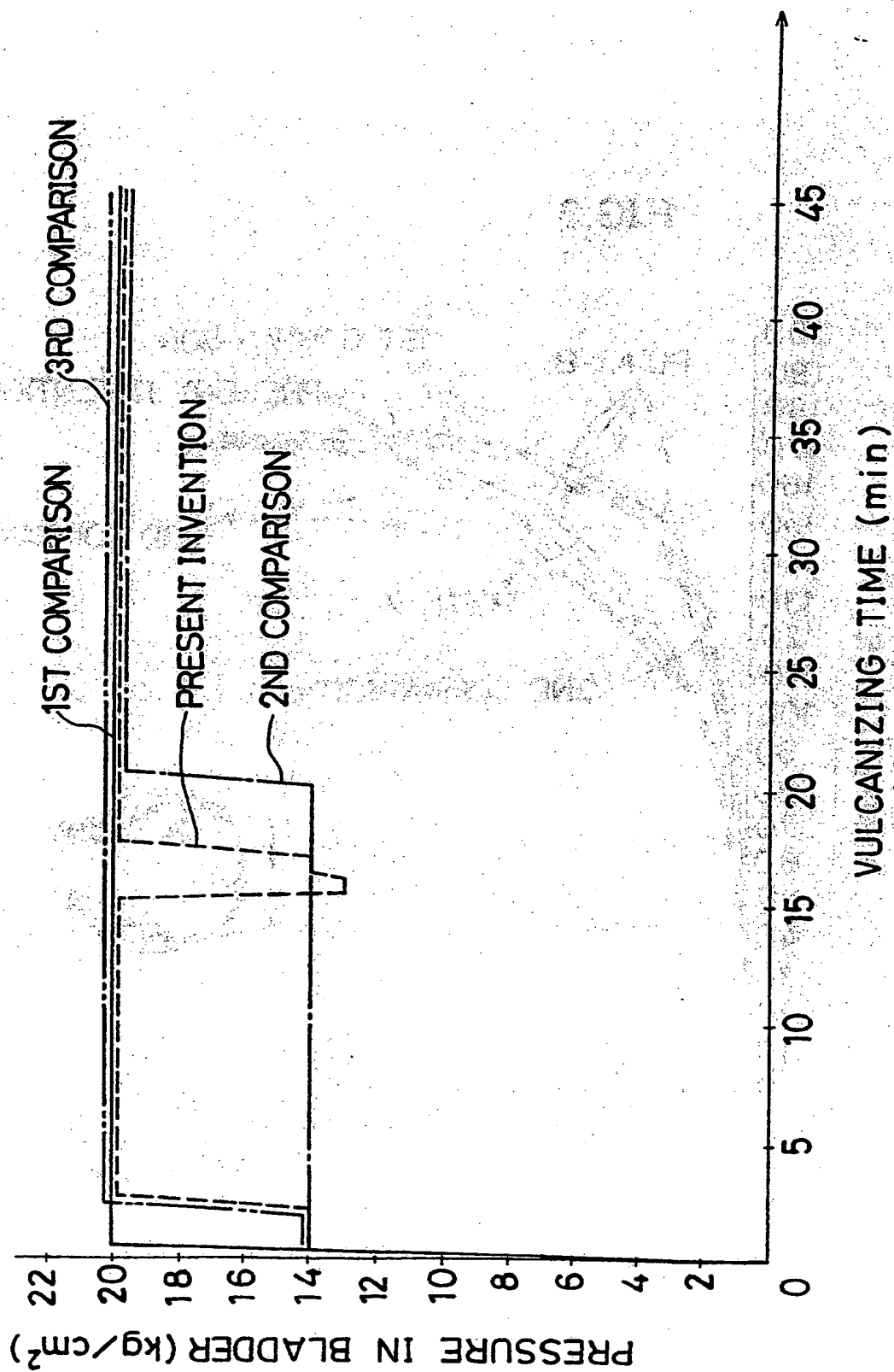


FIG. 5

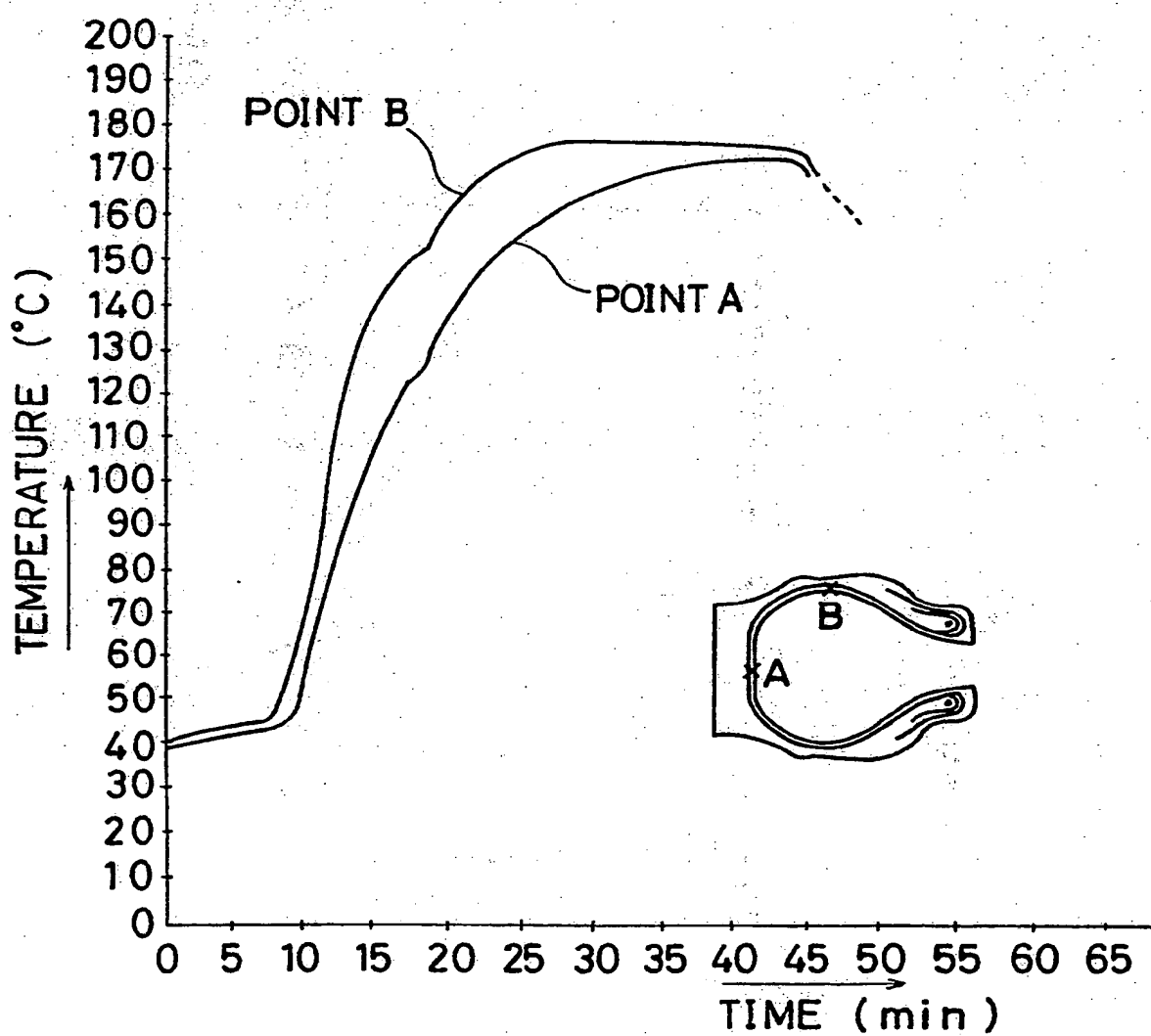


FIG. 6

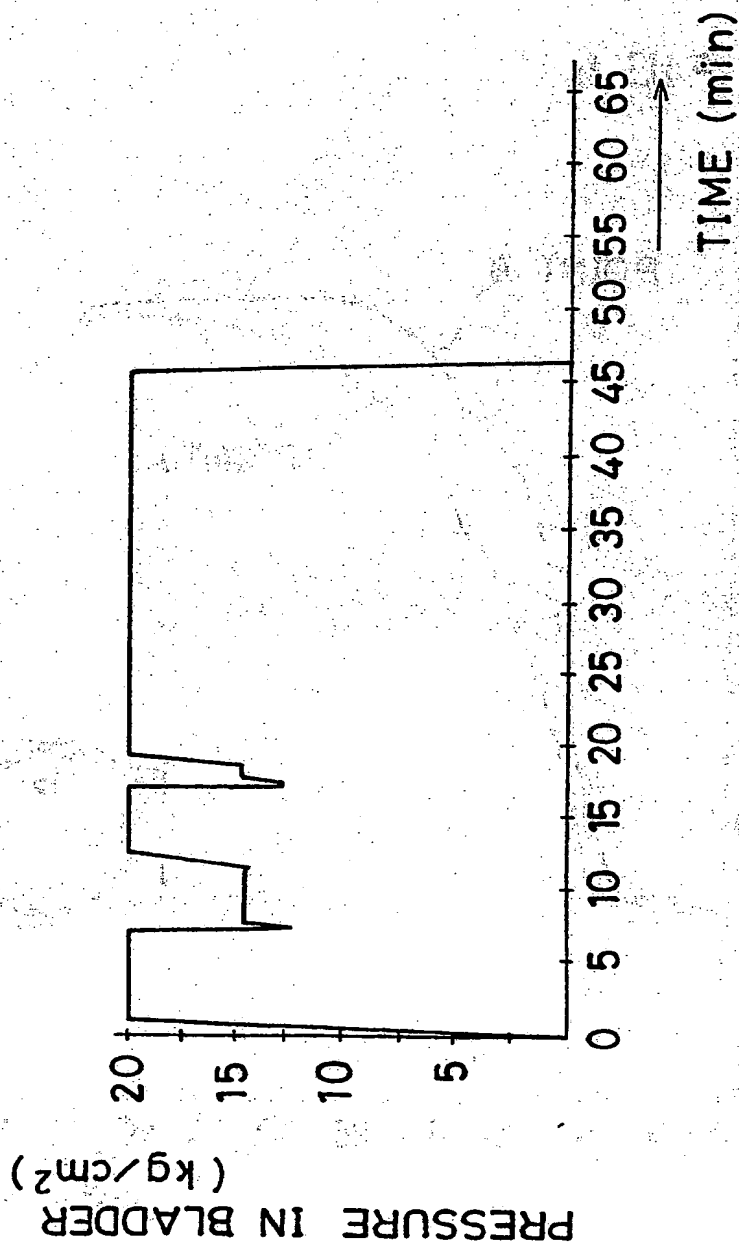
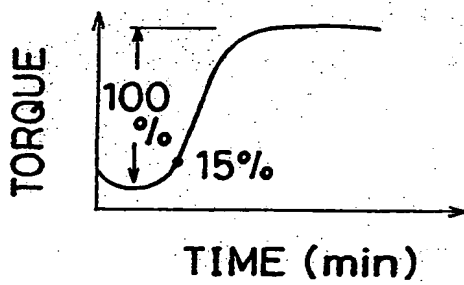


FIG.7





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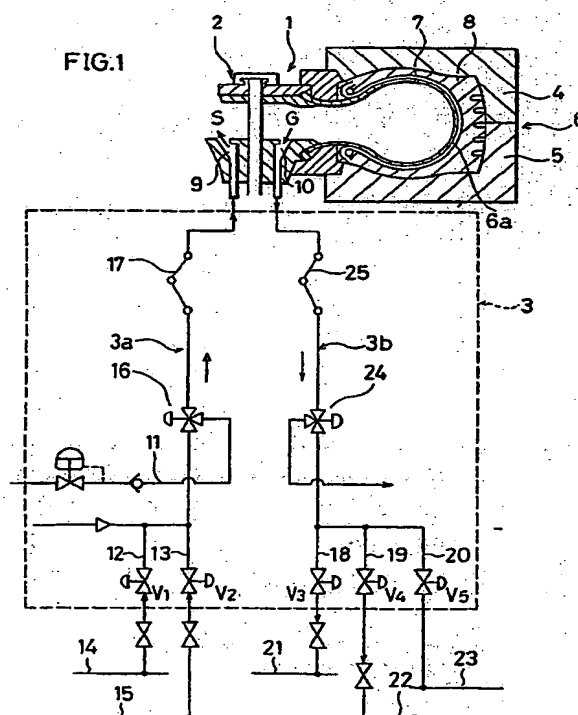
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FIG.1



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## EUROPEAN SEARCH REPORT

Application Number

EP 90 31 3940

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL5)
A	EP-A-323 164 (SUMITOMO RUBBER INDUSTRIES) * abstract; claims 1-4; figures 1,4 *	1-11	B29D30/06
A	EP-A-50 956 (SUNITOMO RUBBER INDUSTRIES) * abstract; claims 1-8; figures 1-4 *	1-11	
			TECHNICAL FIELDS SEARCHED (Int. CL5)
			B29D B29C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 JUNE 1991	Examiner SUENDERMANN R.O.
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